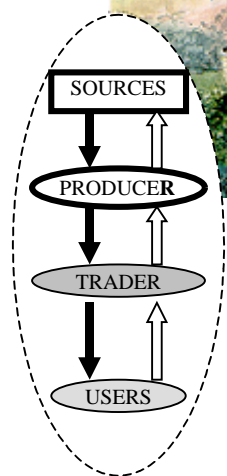


URBAN-RURAL WOOD ENERGY INTERDEPENDENCY IN A DISTRICT OF NORTHEAST THAILAND

By

Anan Polthane, Nongluk Suphanchaimat, and Pongchan Na-Lampang
Faculty of Agriculture, Khon Kaen University



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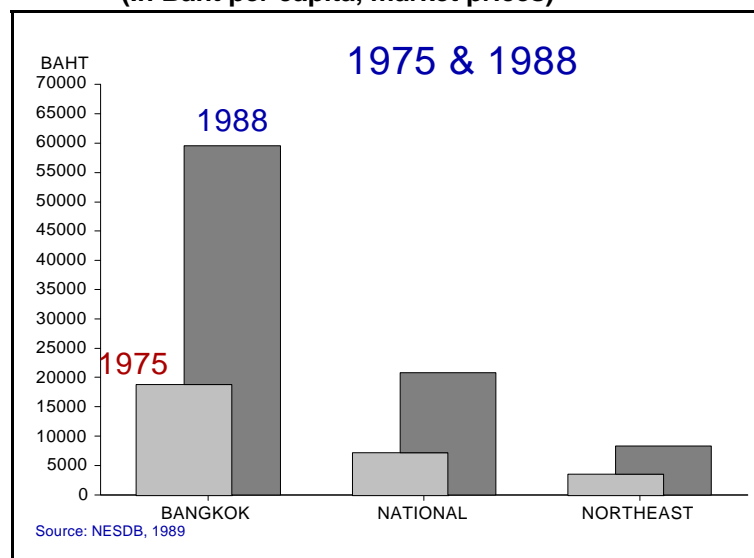
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1. INTRODUCTION

1.1 Country Background

This report is based upon research conducted in the district of Ban Phai, in Khon Kaen Province and the surrounding areas in Northeastern Thailand. Thailand is customarily divided into four major regions: Central, North, South, and Northeast, with Bangkok meriting special attention as a distinct entity. The Central region, containing Bangkok and the Chao-Phraya delta, is the richest and most densely populated part of the country. The Northeast is the poorest region of all. It has been widely perceived to be an area of stagnation and poverty, with poor soils and backward villagers.

**Figure 1 Gross Regional and National Product in Thailand
(In Baht per capita, market prices)**



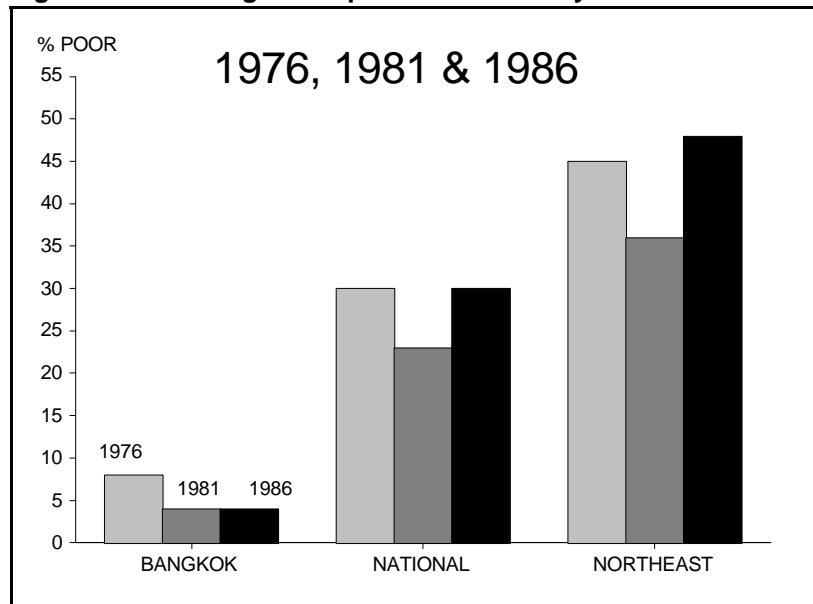
While the Northeast is more dynamic, and the villagers more resourceful, than this stereotype would indicate, it is true that incomes and living conditions in rural northeastern villages are below the national average and they have been falling further behind the surging economy of Bangkok and its environs (Figures 1 and 2).

While most Thai villagers live on valley floors or on floodplains, most rural northeasterners live on rolling terrain. The result is a diversity of land type at the local level in the Northeast, with corresponding high local diversity of soil, moisture, flora, and fauna. Combined with erratic rainfall, these conditions have led rural northeastern villagers to diversify their sources of livelihood, to manage "portfolios" of subsistence activities, exploiting a wide range of social and natural resources to spread risk and serve as a buffer against uncertainty (David Thomas as discussed in T.B. Grandstaff 1988).

The composition of these "portfolios" is changing in complex ways as national development takes place at a rapid rate and the natural resource base shows symptoms of increased stress. There is no more land frontier to spread into. And although the economy in the Northeast grew at

an annual rate of 8.38 percent (market prices) between 1975 and 1986, jobs are still not being generated fast enough to absorb the growing number of young adults who find it increasingly difficult to make a living on smaller and smaller landholdings under unfavorable agronomic conditions and a shrinking resource base. This difficulty is compounded by a growing need for cash in modern Thai society (T.B. Grandstaff, 1988).

Figure 2 Percentage of Population in Poverty



Source: NESDB, 1987

Meanwhile, over the past four decades, and especially over the past 15 years, population growth and economic development have accelerated the conversion of forest land to agricultural purposes. At the same time the demand for forest products has intensified, and deforestation has become an increasingly serious problem all over Thailand. In 1953 about 60 percent of the land area of Thailand, and about 50 percent of the Northeast, remained under forest cover. But by 1985 only 29 percent of the nation and only 14 percent of the Northeast was still covered by forest (Pragton and Thomas 1990: 170, 175-176).

The cutting of trees for wood fuel has often been cited as the cause of this state of affairs, along with logging. Like illegal logging, wood fuel production, especially charcoal making, has gotten a bad press. But in fact the causes of deforestation are multiple and complex. As Panya *et al.* (1988: 1) point out, "such images combine fiction with fact" and while charcoal production has contributed to wood shortages in Thailand and elsewhere, "probably no more than a host of other activities and factors."

1.2 The Use of Woodfuel in Thailand

Several studies have focused upon the total energy consumption of the country. Most studies are, unfortunately, presented in aggregate terms. A study of supply and demand for biomass fuels prepared for the National Economic and Social Development Board (NESDB) in 1987 indicated a high demand for wood fuel compared to other biomass fuels (Table 1).

Table 1 Consumption of Biomass and Its Substitutes, 1980

Consumption	Electricity (million kwh)	LPG (million tons)	Biomass (million tons)					
			Direct	Char- coal	Total Wood Fuel	Paddy Husk	Bagasse	Other Agri. residues
RURAL	109.4	0.011	5.75	3.02	19.3	0.75		
Domestic	66.4	0.011	3.75	2.94	16.9	0.65		0.243
-Cooking	-	-	1.67			0.03		
-Heating & Fumigation	43.0	-	-	0.06	0.27	0.145		
-Ironing	-	-	0.33	0.016		0.061		
Cottage industry								
HOUSEHOLD & TERTIARY (Urban Cooking Only)	636.0	0.125	0.033	0.503	2.28			
INDUSTRY			2.65			1.04	4.40	
Total	745	0.136	8.73	3.52	24.5	1.90	4.40	0.243
x 10 ⁹ MJ [*]	2.68	6.38	142.2	100.6	243.0	23.6	54.60	3.0

* These figures indicate the consumption in terms of heat content, in 10⁹ MJ.

Source: NESDB 1985.

The two major wood fuel consuming purposes are household cooking and small local industry. These industries include the production of charcoal itself, red sugar, Chinese noodles, knives, rock salt, and sweets, as indicated in Table 2. Silk production also consumes huge amounts of fuelwood.

Information from the same study indicates greater fuel substitution (i.e., LPG for wood fuel) among urban dwellers for cooking (NESBD 1985). LPG is more accepted in urban areas because it is easy to use and readily obtainable, but in rural areas wood fuels remain the major source of energy for cooking.

Most wood fuel consumers are small-scale local industries and households. This has prevented the accurate quantification of estimated supply and demand for wood fuels. It has been a generally accepted assumption, however, that level of income and the size and rate of growth of the population are major determinants of wood fuel consumption. In other words, as incomes rise people tend to substitute a higher heat content form of energy, which is normally provided at a higher cost than the low heat content energy (NESDB 1985).

During the past decade, Thailand has achieved its family planning goals, which have slowed

the rate of population growth from over two percent in 1970 to about 1.65 percent in the 1980s. The rural population appears to have a growth rate of 1.5 percent, while the urban growth rate is about two percent (*ibid.*). At the same time, Thailand has enjoyed a high rate of increase in the GDP, which has exhibited an annual rate of increase of about five percent in real terms (constant prices).

Table 2 Fuel Consumption in Selected Home Industries

Product	Technology	Raw material	Fuel	Fuel Consumption Product/Fuel
Fried Banana	Stove	Banana	Wood	NA
Rice	Rice mill	padi	Diesel	330 kg/lit
Sweet (sticky rice)	Stove	Banana, rice	Wood	2.3 kg/kg
Chinese Noodles	Stove	Rice	Wood	NA
Noodle Strainer	Simple forge	Lead, zinc	Charcoal	NA
Rice	Rice mill	Padi	Diesel	63 kg/lit
Charcoal	Kiln	Wood	Grass, wood	NA
Charcoal	Kiln	Wood	Wood	NA
Thai Spaghettii	Stove	Rice flour	Wood	NA
Sweet Rice in Bamboo	Stove, Saw	Sticky rice, sugar, coconut	Coconut frond	4 lit/leaf
Rice	Rice mill	Padi	Diesel	2.5 sacks/lit
Knives, Spades	Forge, tube bellows	Iron sheet	Charcoal	1 knife/kg
Red Sugar	Stove	Sugar cane	Bagasse, wood	NA
Brick	Kiln, mold	Clay	Rick husk	500 bricks/m ³
Wooden Bowls	Motorized	Teak	Electricity	5 piece/kwhr

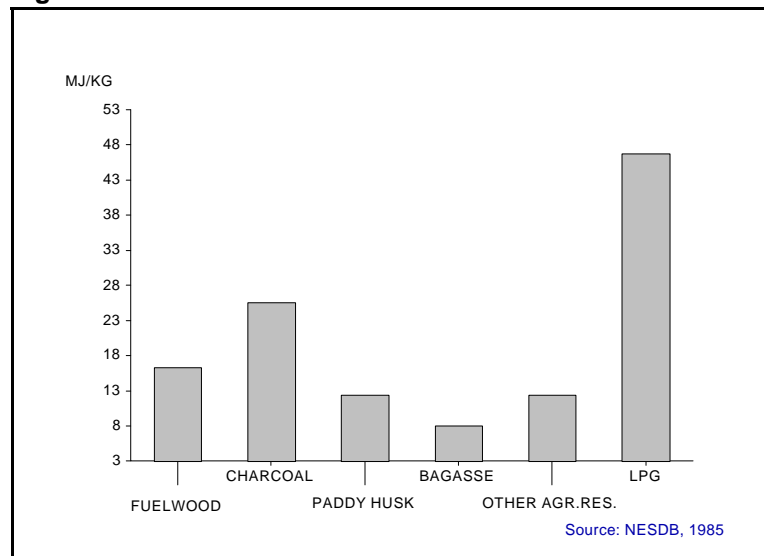
Source: Sompong and Arnold, 1982.

It has been proposed by NESDB that higher GDP and lower population growth is leading people to turn to higher heat content energy sources. As shown in Figure 3, LPG provides the highest heat content, and charcoal provides about 50 percent higher heat content than fuelwood. The use of LPG became significant in urban areas during the early 1980s.

Wood fuels are, however, still consumed by both urban and rural inhabitants alike. Wood fuels flow from rural areas into urban areas. The rapid deforestation that has occurred in recent years has made wood fuels more difficult to obtain. Publicity regarding deforestation and its consequences has aroused public concern about the preservation of forest lands. Public opinion has become conservationist, and many people believe that trees should not be cut, especially for commercial purposes. Thus, while the amount of wooded land has been shrinking, access to and

freedom to exploit that which remains has become more restricted, both by law and by public attitudes. The result has been a high degree of wood scarcity in Thailand, especially in the Northeast.

Figure 3 Heat Content of Fuels

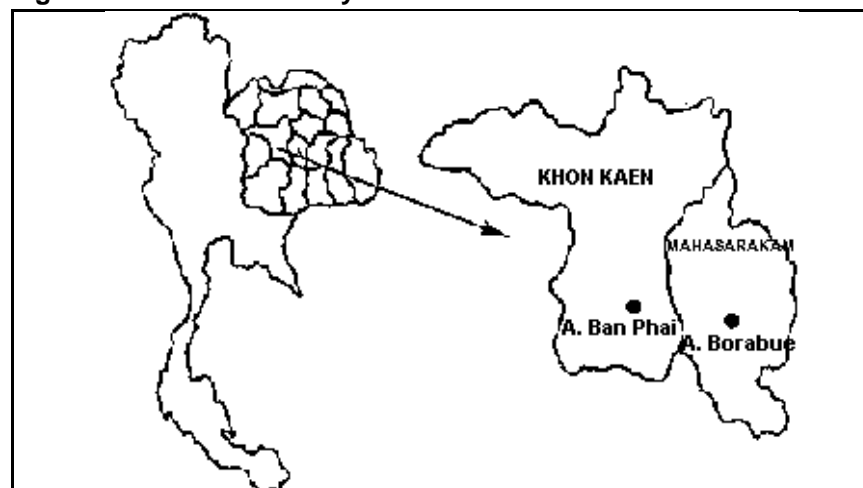


Wood scarcity may have adverse effects on the lives of both rural and urban inhabitants, but not necessarily at the same level. While urban dwellers have various alternative sources of energy to turn to (e.g., LPG, electricity, fuel oil), rural people have to rely mostly on wood fuels. Moreover, to some people, especially those in rural areas, wood fuels are not only a source of energy but are also an important source of income. Thus wood fuel scarcity seems to affect rural populations more severely, especially the rural poor.

1.3 The Study Area

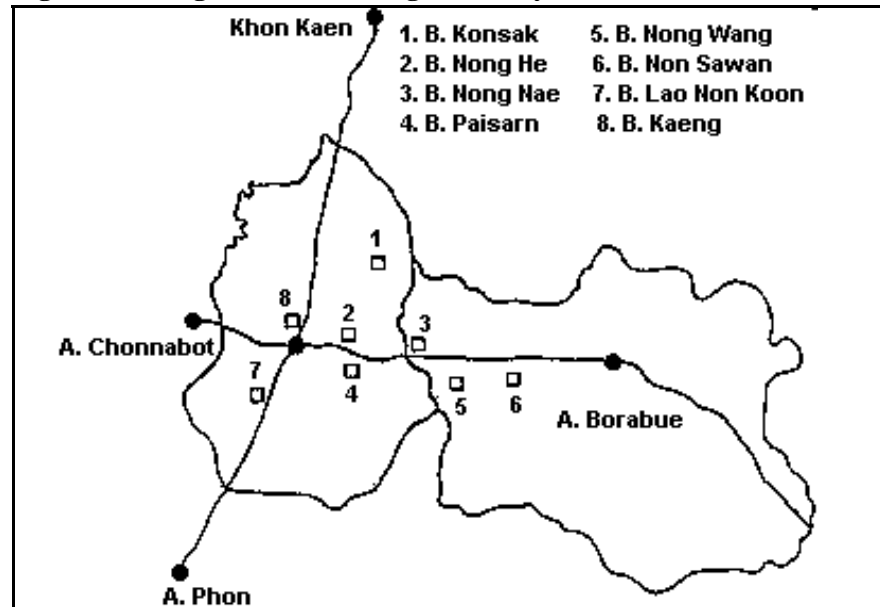
The study area for this research was the municipality of Ban Phai, a district seat in Khon Kaen Province in Northeastern Thailand (see Figure 4).

Figure 4 Location of Study Area



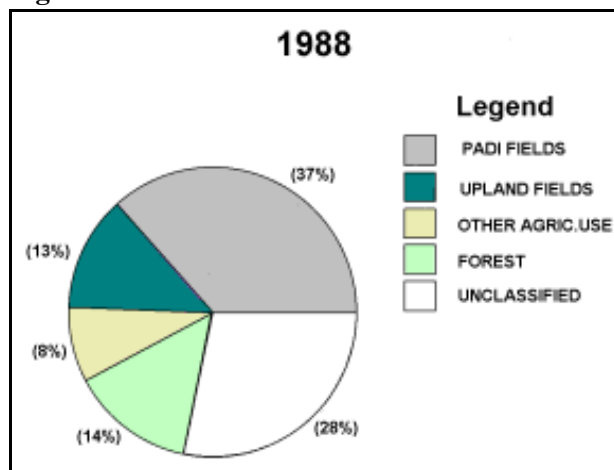
Located about 44 km south of Khon Kaen City, the municipality of Ban Phai contains 20 villages and covers an area of 16 km². Ban Phai district contains 17 sub-districts and 164 villages. It covers an area of 827 km² and contains a population of about 36,184 (1988 figure). Ban Phai was selected for study because it has a variety of industries that rely on wood energy, it is within reasonable travel time of the researchers' base at Khon Kaen University, and it is reasonably representative of the bulk of district towns in the northeast (Figure 5).

Figure 5. Villages Visited during the Study



This is a drought-prone area with an average rainfall of only about 900 mm per year. The most important crops in this district are rice and cassava. In 1986 about 23 percent of the cropland was planted in rice, 74 percent was allocated to cassava production, and most of the rest was in sugar cane.

Figure 6 Land Use in Northeastern Thailand



(Source: Office of Agricultural Economics (OAE), *Statistics*, 1988/1989)

During the past two decades there has been a major shift from kenaf to cassava as the main cash crop in the region. Thirty years ago no significant amount of cassava was being grown in Northeast Thailand. In 1971 about 200,000 *rai* (32,000 ha) were planted in cassava. But by 1988, roughly 6.3 million *rai* (1 million ha) were planted in cassava in the Northeast.

This had a significant impact upon the number of trees grown in and around upland fields, and upland fields have become an important part of land use patterns in the Northeast (Figure 6).

Kenaf, on the other hand, requires a rather heavy input of labor, especially in the retting process. Farmers have good reason to strongly prefer cassava to kenaf as a cash crop, despite the fact that they value having trees on their land and cassava cultivation limits the number of trees that can be grown in the fields.

2. THE PRODUCTION SYSTEM

2.1 A Transition Period

Several decades ago, when forests were still abundant in countryside around Ban Phai, charcoal was made with wood from unclaimed land and public forest in several villages. This charcoal was then sold to merchants in Ban Phai who shipped in by the train load to the Bangkok market. Business was so good that a charcoal merchant persuaded a few charcoal makers from Roi Et Province and other distant places to move into the unclaimed, semi-arid forestland east of Ban Phai and make charcoal for him. The major sources of wood for charcoal production were trees and logs found in the forest.

Informants in the village of Nong Nae (Village number 3) say that when they first arrived, 20 years ago, the forest was full of logs because of a long period of tree cutting by local villagers while hunting for natural foods and logging. Charcoal making activity was able to carry on for several years. Those logs all disappeared within a three-year period during the early 1980s, when a great amount of fuelwood was brought out of the forest to be used in salt making in Borabue district, Mahasarakam Province.

The same thing had happened earlier to the south of Ban Phai when large amounts of wood were taken for railroad construction and for energy. These two events significantly depleted forest areas. The making of charcoal for sale in large quantities by villagers was generally ended about 30 years ago in the area south of Ban Phai and about 15 years ago in the area to the east of Ban Phai when cash crops, especially cassava, were introduced. Most of the remaining forests were cleared and converted into agricultural land.

According to informants, contractors with tractors were hired to prepare the cassava fields, so trees had to be cleared as quickly as possible. An area that would normally have produced wood for two months worth of charcoal production would be cleared in a single day. The dramatic shift to cassava growing, as explained above, had even further implications for the wood energy situation. With 74 percent of crop land in the district devoted to growing cassava, the wood supply in Ban Phai was inevitably negatively affected by this trend.

As a result of all this, wood became scarce. Most of the charcoal makers of years past have turned into full-time farmers. Only those who have no other economic options, such as landless villagers, now earn their living by making charcoal or selling fuelwood. Those migrant villagers who arrived in the area in the early 1970s and turned to making charcoal for their livelihood are still, for the most part, landless villagers. They are known as "professional charcoal makers" (*nag sa daam thaan*). When asked why they did not lay claim to the upland areas they cleared to make charcoal, as other settlers did, they said that although most uplands were still covered with trees and no one had official title to the land, there were claims laid to the land after it was cleared, and these claims were mostly made by earlier settlers. So most of these people have remained landless, and poor. The income they receive from making and selling charcoal has

been very minimal, not enough to allow them to purchase agricultural land in the village.

The clearing of forests to grow cash crops and cutting down trees to provide fuelwood for the salt-making factory in Borabue left a great number of stumps and roots on the land. These wood materials are scavenged by landless villagers for use as wood fuel.

2.2 Charcoal Production

2.2.1 Producers

There are two main types of charcoal producers in the areas around Ban Phai: landless villagers and small landholders with medium or low incomes. Landless villagers in several villages engage in making charcoal for sale on a full-time basis. There are two main reasons for this. First, these people have a lot of experience in charcoal making. Some of them migrated to the area at the instigation of charcoal traders. Second, they have few or no economic options, such as off-farm employment. Other villagers from low or middle income level households occasionally make some charcoal for home consumption and sell some once in a while to get additional income. In one village where wood in agricultural land is relatively abundant, some villagers made charcoal to raise money to pay for the installation of electricity in the village.

2.2.2 Wood Sources

In the past, wood was obtained from unclaimed forest land, sawmills, and lumberyards. There was a sawmill near Ban Phai that provided left-over wood for making charcoal. The charcoal produced was shared equally between those who made it and the sawmill owners. However, the sawmill began reducing its production several years before it finally went out of business four years ago due to wood scarcity.

Wood for making charcoal now comes primarily from privately owned or claimed lands and from village common land. Because of wood scarcity, farmers usually conserve all trees in their fields for future use, such as in home building. The trees are not cut, but are pruned every other year. Only small dead trees not fit to use for lumber, branches, stumps and roots, or crooked trees are available for making charcoal. If a whole tree is needed, one has to buy it, and usually it will be used for construction, not as fuel.



A Professional Tree Pruner at Work

Left-over branches and reasonably large chunks of scrap wood are used for charcoal, while smaller pieces will be burned as fuelwood.



Branches of Trees in Cassava Fields Are Cut Off to Prevent Shading; These Are Used as Fuelwood

Villagers often collect small pieces of wood whenever and wherever they can, as in going to and from the fields. They then store the wood under their house or in their field resting hut. Sometimes children help in wood collection.



Fuelwood from Tree Stumps Carried Home by Pushcart

2.2.3 Wood Acquisition

While landowners collect wood materials from their own land, landless producers of wood energy "beg, barter, buy, or even collect without permission" from those who have a source of wood. In Ban Nong Nae (Village Number 3), where wood is so scarce that landowners conserve any available wood materials that might be used for making charcoal for their own household use, landless producers have to travel far from their village to obtain wood. In areas where wood is not so scarce, people can acquire wood materials around the village or from village common land. If enough wood is available to fill a kiln, charcoal is usually made on the spot where the wood is found. But sometimes people must collect smaller amounts of wood from various places and carry it back to the village in pushcarts and make the charcoal there.



Gathering Small Branches for Fuelwood
in a Wood scarce Area

In one wood-scarce village (Village Number 2) villagers occasionally rent a pickup truck and go as a group to a reserve forest in Chonabot District, to the west, to gather wood and other forest products. The wood is equally divided within the group. Informants report that the wood obtained on such a trip usually is enough to produce sufficient charcoal to be used by their households during the rainy season. They also said that they could not do this often because the truck owner did not want to risk being questioned by the police.

2.2.4 Types of Wood

When wood was still abundant only certain tree species, usually hardwoods, were used for making charcoal. Preferred species included *Shorea obtusa* (*jik*), *Shorea siamensis* (*rang*), *Sindora siamensis* (*tae*) and *Irvingia malayana* (*kabok*). As the size of wooded areas decreased, both hardwood and softwood trees became scarce. So at present charcoal producers do not limit themselves to any preferred species, but use all kinds of available wood materials to make charcoal, including soft wood. Most producers know that charcoal made from certain tree species has better quality, gives a greater weight, and can be sold at a higher price than charcoal made from other species. Their priority has now changed, however, from producing high quality charcoal to producing as much charcoal as possible, of whatever kind.

2.2.5 Transformation

In the past three types of kilns could be found in this area: an oven type kiln (*tao op*), an elongated mound kiln (*tao yeab*), and a shallow pit kiln (*tao phee*). The oven type kiln was used when wood was still abundant and wood was available from the sawmill. It took at least two weeks to prepare the kiln and the wood; but it produced good quality charcoal that sold for a higher price. One informant reported that a sack of charcoal produced in an oven kiln was priced at 100 Baht (US\$4), while that produced in a shallow pit kiln would sell for only 80 Baht (US\$3.20) per sack.

The oven type kiln could also be permanently built and used many times. It was, nevertheless, never widely adopted by producers in this area. The main reason it failed to be widely used was the need to transport wood from where it was found to the kiln. The large-capacity oven type kilns that did exist in this area were abandoned several years ago when wood became so scarce that the labor and time required to transport wood to the kiln became too great, and it took too much time to find enough wood to fill the kiln.



Charcoal Making in Shallow Pit Kiln, Covered with Rice Husk

There are two types of kilns currently used in this area, shallow pit kilns and elongated mound kilns. The shallow pit kilns are small and either round or oval in shape. They are usually built on vacant lots within or just outside the residential area of the village. In making charcoal the wood is placed in the pit, the stack is lit from the bottom, and the pit is covered with rice husks. The conversion process is completed when the rice husks turn to ash, usually in about two or three days. The kiln is then allowed to cool before the charcoal is removed.

This type of kiln is relatively simple to make and to use, so it is widely used by villagers who make charcoal only occasionally for home consumption or additional income.

Because shallow pit kilns produce charcoal of low quality and involve a high degree of waste, all those who regularly make charcoal for sale use elongated mound kilns, which produce higher quality charcoal with less waste. This type of kiln is rectangular. It is bigger and has a greater capacity than the shallow pit kiln, as shown below. The size of kiln desired depends on the amount of wood that is available.



Elongated Mound Kiln

In the past, when large trees were used in making charcoal, massive kilns--50 meters in length--were common. The typical kiln now is only about two or three meters long, 1.5 meters wide, and one meter high, producing about three sacks of charcoal at a time. Such kilns can be constructed in a single day virtually anywhere, but they are commonly built near wherever the wood is to be found. This saves the time and labor of transporting heavy loads of wood. But if the soil around the source of wood is not suitable for kiln construction, if it is too dry or too sandy, the wood is carried to some other place where the soil is more appropriate.

When making charcoal, the wood is stacked horizontally and the stack is then covered with chunks of sod dug up from around the stack. Where sod is not available, the stack is covered with green tree leaves and then earth from around the stack is placed on top of the leaves. A fire is set at one end and left to burn progressively down the length of the stack. Two to four holes, depending on the length of the kiln, set 50 cm apart, are made along the two sides of the kiln. The color of the smoke emitted from these holes indicates the condition inside the kiln. When the smoke coming out of a hole is blue, carbonization is considered to be complete in that section of the kiln and the holes are sealed. That section of the kiln will then be stamped with feet or heavy objects and left to cool. The charcoal will be removed a few days later, after it has cooled. This may be done while the wood in other sections of the kiln continue to burn. Thus, the process of making charcoal takes place gradually, moving from one end of the kiln to the other. Such elongated mound kilns are used exclusively by those who make charcoal for sale. Most producers who make charcoal only occasionally, especially if they make it for home use, say they do not know how to make charcoal using this type of kiln.



Fired Clay Kiln Dug into an Earth Mound

2.2.6 Purpose

The purpose of charcoal production is highly correlated with the type of producer. Most villagers who have access to wood and sufficient labor available make charcoal for home consumption. Some villagers who do not have labor may ask relatives or neighbors to help cut down a tree. The tree is converted to charcoal, which is divided between the tree owner and those who contributed labor. People who have ample charcoal on hand may sometimes sell charcoal when they need cash. But most households do not make charcoal with the intention of selling it.

Poor or landless households, on the other hand, usually produce charcoal for sale. Many landless households have no economic alternative to charcoal making. This phenomenon is exemplified by a group of villagers in Ban Nong Nae (Village Number 3) who are known among the villagers as professional charcoal makers. These people receive most of their income from the production and sale of charcoal. Some people in this village have off-farm employment, but for other villagers, at least six households, charcoal is the main source of income.

2.2.7 Constraints and Problems

The main problem in charcoal production in the Ban Phai area is wood scarcity. Most forest areas have either been claimed and converted to agricultural use or have been closed to any exploitation by villagers. All villagers feel the pressure of wood shortage. Even those who have trees on their land only prune branches to use as fuel in their households. They try not to cut any trees except for building purposes.

In some villages, very few trees are left in the fields. Even tree stumps and roots are conserved. Those who suffer the most from wood scarcity are the landless villagers who make and sell charcoal to earn a living. They have to buy wood materials rather than freely gather or beg them as they once did. Other villagers, mostly land owners, claim that charcoal makers often collect wood from the fields without obtaining permission. The need to buy wood increases the cost of

production and reduces profits. Moreover, charcoal producers have to travel further and further to collect the wood they need. But despite their travels, the amount of wood they are able to acquire is getting smaller and smaller. Most people do not want to sell even stumps or roots, let alone trees. Landless charcoal producers in Ban Nong Nae (Village Number 3) said that in the previous month they had earned only about 1,000 baht (about US\$40). Some months they make even less than that.

Although the vast majority of villagers can make charcoal, only a few of them can do it well. The easy-to-use but very inefficient shallow pit kilns are widely used. With any type of kiln, expertise is necessary to reduce wastage. Professional producers in Ban Nong Nae complained that they could produce double the amount of charcoal that most villagers can from the same amount of wood.

2.2.8 Adjustments

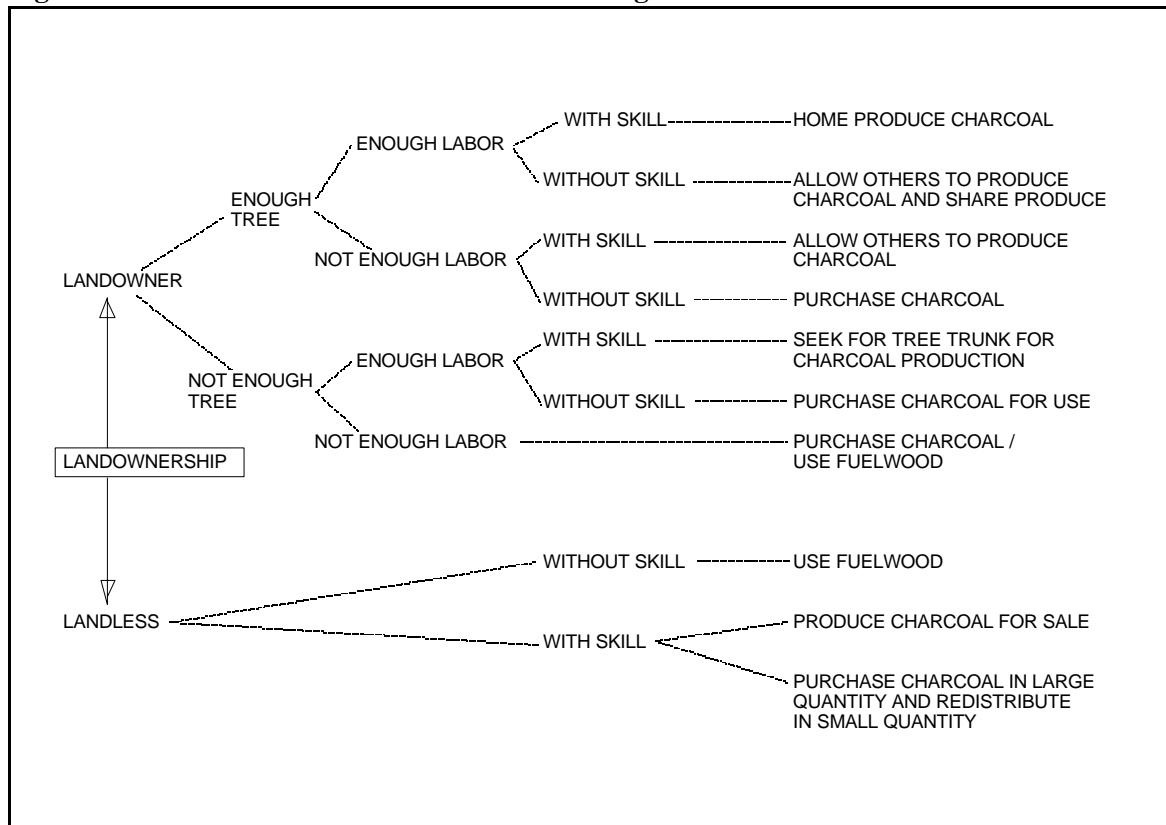
Charcoal producers have adjusted to wood scarcity in several ways. These measures are intended to get as much charcoal as possible from a declining supply of wood. There is now, for all practical purposes, no such thing as tree species preference. People use every part of every tree: branches, stumps, and roots, hardwood and softwood, whatever wood they can obtain. They have also refined their production techniques. They have reduced wastage and they have managed to improve the quality of charcoal that they can make from soft wood. Charcoal is left in the kiln until it has completely cooled, especially if it has been made from dry wood, in order to improve its quality.

2.3 Fuelwood Production

2.3.1 Types of Producers

Many rural households throughout the district produce fuelwood for their own (and to less extent others') use, but most of the fuelwood sold in Ban Phai comes from Ban Nong He, located about 15 km east of Ban Phai on the highway to Borabue. All the fuelwood for sale in this village comes from the members of 37 landless households. They got into this business about eight years ago when fuelwood was in demand for making salt. When asked why they produced fuelwood instead of charcoal, they gave two reasons. First of all, they said, they were able to get cash quicker from fuelwood. And secondly, they added, they didn't know how to make charcoal. The options for these villagers as compared to landowning villagers are schematically presented in Figure 8.

Figure 8 Charcoal and Fuelwood Decision Making



2.3.2 Wood Acquisition

All forests in the area are now closed to exploitation, so the only source of wood is the agricultural land around the village. Producers beg or buy wood materials, mostly tree stumps, from the landowners. Only small dead trees and the upper parts of tree stumps cut close to the ground are used to make fuelwood for sale.

Wood is transported to the village using a pushcart that is towed behind a motorcycle. Some producers, who cannot afford a motorcycle, push their carts by hand, but this severely limits their searching range to a few kilometers around the village. Those with motorcycles, on the other hand, go 10 or even 20 km away in search of wood. In these households, both husband and wife engage in collecting wood. The man often needs either his wife or a friend to help use a two-person saw. Sometimes, if a woman is hired to weed a field, her husband will be cutting tree stumps nearby.

2.3.3 Kinds of Wood

Due to wood scarcity, every part of every size and species of tree may be used for fuelwood. So long as it is dry and can be easily split into straight pieces, people are glad to acquire it. In this village that is the primary source of fuelwood sold in the district, roots are seldom used because so much time and labor are required to dig them up and, once obtained, they are very

difficult to split because of their odd shapes. But we found a village in the Chonnabot area where wood is even more scarce than it is around Ban Phai. There roots are dug up and carefully split into small pieces of fuelwood for sale in a nearby district market (Chonnabot). Producers in this village do not supply fuelwood to the Ban Phai market.

2.3.4 Transformation

Logs are cut into sections about 50 cm long in the fields and then taken to the producer's house. They are then split length-wise into convenient sizes using a long handled axe. These small pieces of fuelwood are tied together three to a bundle. The bundles are then stacked to be shipped to market the following morning, as shown below.



Bundles of Fuelwood Piled before Shipping to the Market



Piled Logs for Splitting into Small Sized Fuelwood

2.3.5 Purpose

In Ban Nong He fuelwood is produced solely for sale in the Ban Phai market.

2.3.6 Constraints and Problems

The main problem of fuelwood making in Ban Nong He is wood scarcity. All around the village, tree stumps, which are the major remaining source of wood, have either been used or are being conserved by their owners. To find wood, producers of fuelwood must now travel far from the village. This consumes both time and money. Most producers own motorcycles to tow their pushcarts, which are loaded with pieces of logs from the fields or with fuelwood on its way to the market. Those who do not own motorcycles must push their carts to bring the logs in from the fields, but the market is so far away that they cannot get their fuelwood to the market that way. So these fuelwood producers must sell their fuelwood to collectors in the village. Trucks are never used to transport fuelwood because the risk of being arrested is too great.

3. THE DISTRIBUTION SYSTEM

3.1 Distribution of Charcoal

Within charcoal making villages (i.e., Villages number 3 and number 5, and others in the vicinity), charcoal is distributed in many ways. It is shared and borrowed among relatives and friends; bartered or borrowed by low income households; or sold either to wealthier households or to local charcoal traders. Except for those who make charcoal for sale, most villagers do not seem to be willing to sell the charcoal they have made. This seems to be mainly because wood scarcity is so great that most people have barely enough for their own use. Producers who make charcoal only occasionally and primarily for home consumption usually sell charcoal only when they are in serious need of cash, such as to pay for essential medical treatment. Those who make charcoal for sale but do not want to take it to the Ban Phai market themselves usually sell it either to those fellow villagers who do charcoal retailing in town on a regular basis or to collectors who serve as local middlemen.

3.1.1 Distribution to and within Ban Phai Municipality

Nearly all of the charcoal supply in the Ban Phai market has been brought there by a variety of small-scale entrepreneurs who live in rural areas. At present only a few types of vehicles are used to carry charcoal from production sites to the market: small and medium-sized trucks owned by local middlemen, mini-buses running from the villages to town, and horse carts. Pushcarts are not used to transport charcoal. This may be because the charcoal-producing villages are so far away from town. The big buses do not permit charcoal aboard because it is too dirty.

In the past, producers in the villages located along highways displayed big sacks of charcoal by the roadside for sale to passing motorists or truckers. This marketing strategy is no longer practiced because the risk of being arrested is too great. Most producers, including those who make charcoal for sale, sell their product to local middlemen or local retailers instead of selling it in town themselves. Too much time and effort is required to retail charcoal to make it worthwhile to anyone except the specialist or those in special circumstances. Some producers, for example, especially those who make charcoal only occasionally, sell their charcoal directly to urban traders, by having local mini-bus owners deliver it to town and conduct the transaction for them.

There are two different groups of local collectors in the study area. Those who do business in the area east of Ban Phai act as professional middlemen who buy charcoal and transport it with their own trucks to sell to retailers in the Ban Phai market. These collectors do not make charcoal themselves.

One of these collectors, who lives in Village number 4 and owns a four-wheel truck, has a complex symbiotic relationship with the group of poor villagers in Village number 3, who have to some extent become dependent upon him. He travels widely, using his truck to deliver cassava to market for farmers. This gives him a marked advantage in locating and obtaining wood, stumps, and roots, which he hauls back in his truck after delivering the cassava.

He will ask some charcoal makers in village number three to make charcoal out of this wood for him, providing them with rice sacks and a cash advance for their expenses, to be charged against the wages for their labor. Instead of selling this charcoal to urban retailers as other collectors do, this collector sells the charcoal to those villagers (mostly but not entirely from Village number 3) who wish to earn some extra money by in effect working as sales people. He will take them and the charcoal to town, leaving early in the morning, perhaps as early as 4 A.M.

He sells the charcoal to the villagers for about 80 baht (US\$3.20) per sack, charges them another eight baht (US\$0.32) per sack to take the charcoal to town for them, and then charges each villager yet another five baht (US\$0.20) a piece to take them to town along with the charcoal. But they do not actually have to pay him any money until after they have sold the charcoal. It is at this point, however, technically their charcoal. If he is questioned by authorities on the way to town about transporting such a large amount of charcoal, each passenger claims a portion of the load, so that no one person possesses more than the legal limit. The collector must, nevertheless, pay "unofficial fees" on a monthly basis as well as occasionally "on demand" to continue this practice.



Sacks and Bamboo Baskets Used as Charcoal Containers

This retailer could more easily and quickly sell his charcoal directly to urban retailers, as most other middlemen do. But, he says, he wants to help the poor villagers make some extra money by selling charcoal. At the same time, he is able to sell his own charcoal at a higher price. But the villagers do benefit too. They make their profit by repacking the sacks of charcoal they have "purchased" into small bamboo baskets which they sell door-to-door in the town. Far from feeling exploited, these poor villagers sometimes will call upon this collector to organize another sales expedition to town.



Charcoal Put in Bamboo Baskets by Retailers



Charcoal Repacked in Plastic Bags by Retailers

The second group of collectors do business in the area about 25 km northeast of Ban Phai. They are actually producers cum collectors, who both make charcoal themselves and buy it from their neighbors to take to urban retailers in Ban Phai by means of horse carts. One horse cart load consists of seven small sacks of charcoal or three large ones. They leave their village after dinner in groups of four or five carts and arrive in Ban Phai very early in the morning. They sell their charcoal in bulk to urban retailers and make no retail sales themselves. This group of traders is composed entirely of men, most of whom come from poor or landless households.



Horse Carts Used in Charcoal Transport to Ban Phai Market

Nearly all of the rural retailers selling charcoal to consumers in Ban Phai municipality come from one distinct neighborhood of Ban Nong Nae. This group of traders is composed of women, both young and old, who come from very poor and mostly landless households and have no other economic alternatives. One key informant from this group has been in the charcoal business for 25 years.

It is claimed by retailers, and admitted by producers, that retailing charcoal requires a lot of skill. It is especially important to have the knack of repacking charcoal from sacks into small bamboo baskets and filling the baskets using as little charcoal as possible. The "increase" in volume created by skillful packaging makes the business profitable. One key informant reported that on her first few days in the business she actually lost money because she did not know how to repack the charcoal in the most advantageous way. In most cases, a retailer can sell one large sack of charcoal per day, earning about 30 baht (US\$1.20) net profit. This income is quite small, even compared to the earnings of workers in the cassava or sugar cane fields.

At present there are two urban collectors in the Ban Phai municipality who also sell charcoal directly to consumers. They buy charcoal from both producers and local middlemen, as well as from any other villagers who will or must sell charcoal. Most transactions are conducted at their establishments, although when supplies grow low they may venture out to seek charcoal. Sometimes they must provide advance payments to insure themselves of a constant supply of charcoal. This usually occurs during the rainy season, when villagers are busy growing rice and do not have time to make and sell charcoal. These collectors either repack the charcoal into small plastic bags which they sell to small-scale consumers such as urban households or food vendors or they sell it in big sacks to large users, such as restaurants. Urban retailers of all kinds repack charcoal for small-scale users.



Sacks of Charcoal Distributed by Urban Distributor with Tricycle

Other small-scale retailers in town are small grocery stores and retailers of milled rice. These retailers usually buy charcoal by the sack and fuelwood in big bundles and then repack them into smaller quantities. They display only a few plastic bags of charcoal at a time to avoid questions from officials. Their customers include urban households and villagers from several villages around Ban Phai where wood is extremely scarce.

3.1.3 Constraints and Limitations

Both charcoal availability and charcoal consumption vary according to the seasons. In the rainy season the demand for charcoal is high, because of the dampness, but the charcoal supply at this time is very low, because most charcoal producers, even many of those who are landless, are heavily engaged in farming activities and do not have time to make charcoal. This causes some problems to most distributors, and local middlemen must spend more time and more money to acquire charcoal.

Urban collectors have to go out to collect charcoal actively instead of merely waiting at their establishments for people to bring it to them as is the case other times of the year. This increases the cost of the charcoal. We found that this constant variability in the availability and price of charcoal was one of the main reasons why some users turned to other energy sources. Their livelihood was, in many cases, in the hands of local collectors who had to find enough charcoal to sell to meet the demand. Some collectors found themselves waiting for days without earning any money because they could not purchase any charcoal.

Any distribution of charcoal outside the producer's own village is greatly affected by legal regulations. The law states that unlicensed individuals can possess only .5m³ of charcoal, or about three sacks (Panya *et al.* 1988). All the rural distributors, none of whom are licensed, know about these regulations and try not to transport any large amounts of charcoal. Urban middlemen must also pay "unofficial fees." It appears that any large-scale activity by either producers or distributors is discouraged.

All traders interviewed complained about the decreasing demand for charcoal. Even though charcoal is still widely used as a primary energy source by low income urban households, the middle and upper income level households have begun switching to alternative fuels, such as LPG and electricity. Charcoal, they feel, is unreliable in supply, dirty, and inconvenient to use. This switching appears to be irreversible, (at least, given current pricing trends). Once users have turned to other fuels, they will no longer use charcoal except as a supplementary fuel.

Product quality is also a problem to charcoal distributors these days. Because of wood scarcity, producers use all available wood to make charcoal. Charcoal made from soft wood, or from dry wood, burns very quickly and produces much ash and smoke. It is thus considered to be poor quality charcoal. Some users still demand good quality charcoal, but this demand is not easily met and a reliable and continuous supply cannot be assured by distributors.

3.2 Distribution of Fuelwood

3.2.1 Local Distribution

Like charcoal, fuelwood is shared among relatives and friends, but we found no trading of fuelwood among villagers, at least not for household use. This may be because those villagers who purchase fuel are among the wealthier village inhabitants, and they prefer charcoal to fuelwood.

3.2.2 Distribution to and within Ban Phai

At present, virtually all of the fuelwood sold in Ban Phai municipality is from Ban Nong He (village number 2), about 15 km to the east of town. It is transported solely by the fuelwood traders of Ban Nong He, of whom there are two types: producers/retailers and collectors/middlemen. Because the fuelwood market is narrower than that of charcoal, traders must have some regular customers to whom they can sell fuelwood quickly and directly. Only producers who have established relationships with regular customers bring their fuelwood to Ban Phai to sell themselves. The rest sell the fuelwood they produce to local middlemen, themselves former producers who managed to build up a regular clientele of sufficient size to enable them to sell fuelwood for others.



Fuelwood Transport by Motor Tricycle

All fuelwood traders use motor tricycles or push carts towed behind motorcycles to transport fuelwood to Ban Phai. They typically make one trip per day, in the morning. They sell the fuelwood to regular customers. Their customers are either end-users (i.e., silk extraction plants, pork processing shops, food vendors, small restaurants) or one of the two urban charcoal collectors described above, who resell it to other users later. Only small users such as food vendors buy fuelwood from these two urban collectors. Among these customers are villagers from wood scarce villages around Ban Phai who use fuelwood to boil water for silk extraction in their households.

3.2.3 Constraints and Problems

Due largely to the extensive publicity devoted to the claim that cutting trees for fuelwood is the major cause of deforestation, and the subsequent widespread negative public attitudes toward woodcutting, local officials are even more strict in regulating the transportation and marketing of fuelwood than they are in regard to charcoal. This effectively discourages many producers from transporting and selling themselves the fuelwood they produce. Instead, they opt to sell it at a lower price to local collector/producers who specialize in the transportation and marketing of fuelwood.

These fuelwood traders have to pay the ubiquitous "unofficial fees" at an even higher rate than the charcoal traders. They must also accept the risks and inconvenience of travel at very unusual times, very late at night or very early in the morning.

As is the case with charcoal, fuelwood is gradually being replaced by other sources of energy. This is a general trend. For example, the Chinese medicine store now brews its nostrums with fuel oil. Some food vendors have switched to cooking with LPG. Various other fuelwood users, such as the silk extraction plant and many pork processors, are now thinking about switching to some other type of fuel.

4. THE CONSUMPTION SYSTEM

4.1 Use of Wood Fuel in Rural Areas

In the rural areas where charcoal and fuelwood are produced to supply the Ban Phai market, most households use both charcoal and fuelwood. Villagers prefer charcoal to fuelwood in cooking because it is cleaner and more convenient. Some villagers complain that the soot and grime produced by burning fuelwood makes their houses, and even their cooking utensils, dirty. Also, when cooking with fuelwood the fire has to be tended closely to feed wood into the fire at just the right rate. Otherwise, not only might the food be spoiled, but there is a real danger of fire. Glutinous rice cooked in bamboo containers is a common dish that is especially hazardous if cooked with fuelwood and left unattended. This is one of the main reasons why people cook more with charcoal during the rainy season, when everyone is busy going to and from the fields and busily engaged in the many activities necessary for growing rice. Moreover, charcoal is easier to keep dry in wet weather than the bulkier fuelwood.

Those rural dwellers who must purchase their fuel, and those who can afford to buy it--well-off villagers, school teachers, local merchants--buy charcoal within the village. Landless villagers, who must from day to day scramble to find bits and pieces of wood to use to cook their meals, have no choice but to continue to use fuelwood. Fuelwood is also necessary in silk extraction, because with fuelwood it is easier to regulate water temperature by pushing pieces of fuelwood in or out of the fire as desired.

In the past, most villagers used wood fuel made from hard wood. They also avoided using taboo trees for making charcoal or fuelwood. But now, because of wood scarcity, only one active preference persists. People still attempt to find *Shorea obtusa* (*jik*), *Shorea siamensis* (*rang*), or *Sindora siamensis* (*tae*) wood to burn to warm a post-partum resting mother. In some villages to the south of Ban Phai, wood is so scarce that even dry cassava stems are used as fuel for cooking and as a supplementary fuel in silk thread extraction.

4.2 Use of Wood Fuels in the Urban Area

4.2.1 Urban Households

Until recently most households in Ban Phai municipality used charcoal for cooking and other household uses, such a boiling water to make coffee or for bathing in the winter months. Now, due mainly to an unstable supply and rising prices, more and more households, especially those in the middle and upper level income groups, have turned to LPG to meet their household energy needs.

Most people who use charcoal are initially reluctant to change to LPG. The initial cost seems rather high, about 1000 baht (US\$40) for installation. But once they do begin using LPG for one reason or another--because charcoal is temporarily unavailable, or if the price soars--they will continue to use it. In part this is because they are reluctant to "waste" their investment, but it is also because once they get used to it they like the convenience of cooking with a gas stove. Some people keep both charcoal and gas stoves and sometimes use both of them simultaneously. The charcoal stove is used for slow cooking; i.e., to cook glutinous rice. The gas stove is for fast cooking, such as preparing side dishes. Some households have charcoal stoves which they use only occasionally, just for roasting or broiling. Because they are so convenient, electric rice cookers are now widely used to cook non-glutinous rice among urban users and middle and upper income rural families. Low income urban households continue to rely upon charcoal for cooking, mainly because they cannot afford the initial investment required to switch to LPG.

4.2.2 Food Vendors and Restaurants

Both fuelwood and charcoal are still major energy sources for food vendors and small restaurants in the town of Ban Phai. Both food vendors and restaurants can be divided into two groups: fuel-specific and non-fuel-specific. Non-fuel-specific establishments include noodle shops and small restaurants selling a variety of Chinese or Thai foods. The most obvious fuel-specific establishments would be barbecued chicken shops or stands that grill snacks over charcoal. Stands that sell fried bananas or fried fish widely use fuelwood, but some of them, too, have switched to LPG.

In general, charcoal is used in preparing foods that need a steady level of heat and have a long cooking time, such as glutinous rice, soups, and curries. On the other hand, when intense heat is needed at a particular time, as in preparing many fried dishes, fuelwood makes it easier to control the temperature. We found that LPG has, to some extent, replaced both charcoal and fuelwood in non-fuel-specific establishments. Electricity and gas are widely used in cooking non-glutinous rice in those establishments.

4.2.3 Small Industries

Several kinds of fuels were found in use by industries in Ban Phai municipality. These include fuelwood, rice husks, sawdust, wood shavings, wood scraps, and coconut shells. Fuel oil has also recently been adopted by a few industries in the area.

The silk extraction factory, which has always used fuelwood to fire its boiler, is one of the major consumers of fuelwood in the area, using about 3-4 motor tricycle loads (each load about one cubic meter) of fuelwood daily. A group of producers (possibly including some collectors) in Ban Nong Nae (Village Number 3) and Ban Nong He (Village Number 2) supply fuelwood that has been specially cut to meet the factory's specifications. The wood is cut so that it is 50 cm long and flat in shape, making it easy to insert into the boiler.

The factory has recently bought wood scraps from a cutting board factory located some 80 km away. According to the owner, this new source of fuel is cheaper, and burns better, than ordinary fuelwood. But the supply is inadequate to meet his demand. Due to the three major problems associated with their use of fuelwood (increasing price, decreasing supply, and the labor costs of tending the fire), the factory is considering switching to fuel oil, which is more economical,

requires less start-up time, and is convenient to operate. Changing to fuel oil, it is felt, could increase capacity, but the initial cost is very high, so at present the change is deferred.

There are two large factories that produce Chinese noodles in Ban Phai municipality. Both of them use sawdust and rice husks as fuels to make steam. Due to the scarcity of sawdust, one plant has already switched to fuel oil.

According to the owner of the other plant, who is still using sawdust and rice husks, sawdust and rice husks can be burned in the same stove, so they can be used interchangeably. He prefers using sawdust, however, because rice husks produce too much ash and smoke that accelerates chimney corrosion. So he uses rice husks, which are relatively abundant locally, only when sawdust is unavailable. For him the acquisition of sawdust is a full-time job. Every day he sends out a truck to collect it from distant sawmills. Sawdust has been very scarce since the government closed all the country's forests to logging in 1989.



Sawdust for fuel in
Thai-Noodle Factory

Thai noodle production is a home industry widely practiced in two villages within the Ban Phai municipality. The fuels used are rice husks and wood residues (i.e., wood shavings, sawdust, and wood scraps) from the furniture factory in Ban Phai. Wood residues are preferred because they produce more heat with much less ash. But wood residues are also scarce.



Wood Shavings for Fuel
in Thai-Noodle Factory

The only steamed fish processing plant in Ban Phai uses rice husks and coconut shells to boil water. This plant, in fact, has a contract to buy all the coconut shells generated by the largest coconut milk producer in the Ban Phai market. Coconut shell is preferred as fuel because of the high heat it produces, but the supply is always too low to meet the demand.



Coconut Shell for Fuel

Ban Phai is well-known for its pork products, especially dried shredded pork and Chinese sausages. Fuelwood is used in preparing dried shredded pork, while charcoal is used in curing Chinese sausages.

4.2.4 Other

Even though a few electric-fired crematoria are available in the town of Ban Phai, fuelwood and charcoal are still used in cremations, which is customary in Thailand. According to a key informant, one cremation takes at least two sacks of charcoal plus some fuelwood. Cremation with an electric-fired crematorium requires an extra half sack of charcoal to complete the process. But charcoal is never used alone in cremation.

4.3 Adjustments

4.3.1 Rural Users

Several measures have been adopted by rural people to cope with the wood fuel scarcity. Burning charcoal or fuelwood is always doused with water or extinguished in a clay pot after cooking and kept for future use. Those who own trees in their fields have taken some steps to conserve them. Instead of cutting the whole tree to prevent the shading of cash crops, they carefully prune them and use the cut-off branches as fuel. Some even grow more trees in their fields.

On land to which they have no secure title, some farmers have tried to plant cashew nut trees, a practice that has been promoted by a private company. However, in general the trees have such low productivity in this area that several farmers are thinking of shifting to other crops. Again, they expect to get some wood for making charcoal.



Cashew Nut Trees in Reforestation Area

LPG is not widely used in rural areas and probably will not be so for quite some time because of high initial costs and high distribution costs. The stove with a stand would cost perhaps 750 baht and the gas container and necessary utensils might cost another 1150 baht. LPG sells for 10 baht per kg and the smallest quantity that can be purchased is 11.5 kg. A household would therefore have to have at least 2000 baht (US\$80) to be able to switch to LPG.

Most villagers are too poor to afford this expense. Moreover, they still fear gas tank explosions, which they hear about from the mass media. It also seems troublesome to them to handle a gas tank. Once the initial investment has been made, however, LPG is not really that expensive to use. A month of cooking might take approximately 70-80 baht (US\$2.80-3.20) worth of LPG, which many villagers could afford.

Some middle income level rural households have bought diesel oil cooking stoves to guard against future fuelwood shortages. These stoves cost about 800 baht (US\$32). According to advertisements, this stove requires only three liters of diesel oil for one month of cooking. This would cost about 27 baht (US\$1.08). According to farmers, this amount of oil actually lasts only eight days. Worse yet, they cannot find any source of maintenance service for diesel stoves in town, so the stoves are left unused.



Diesel Stove

4.3.2 Urban Users

4.3.2.1 Urban Households

Most urban households have coped with wood fuel scarcity by switching to LPG. Because electricity is still expensive, it is generally used only for cooking non-glutinous rice. Neither electric stoves nor electric ovens are widely used.

4.3.2.2 Food Vendors and Small Restaurants

More and more of the food vendors and small restaurants in Ban Phai municipality are switching from fuelwood and charcoal to LPG. Only those establishments that require wood energy for specific purposes, such as barbequed chicken stands, are not substituting LPG for their conventional fuels.



LPG Has Replaced Wood Fuel in Deep Frying Bananas

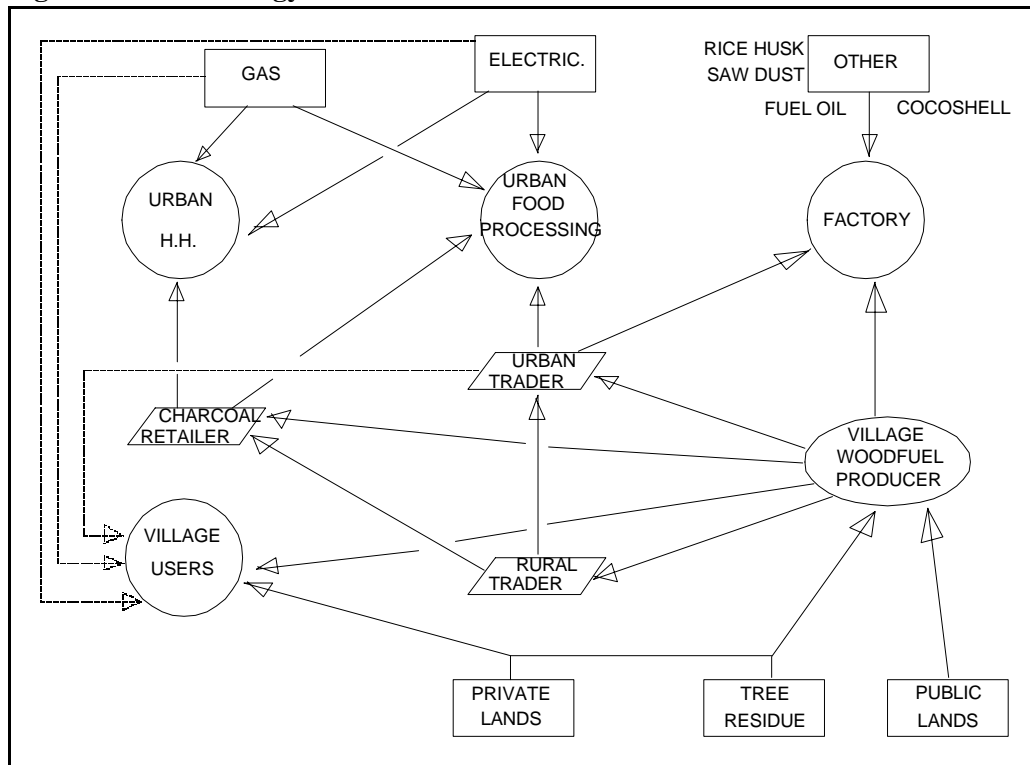
4.3.2.3 Small Industries

As conventional sources of wood energy get more scarce, small industries are looking for alternative sources of energy. Some have turned to other biomass fuels, such as coconut shells or rice husks. Some have switched to fuel oil, which is cheaper and more convenient to use, but has very high initial costs that prevent widespread use.

5. CONCLUSIONS

The wood energy flows between rural and urban areas, as sketched schematically below, forms the basis for our conclusions.

Figure 9 Wood Energy Flows between Rural and Urban Areas



5.1 Rural Dependency on Wood Energy

Wood fuels are important to rural inhabitants not only as sources of energy, but also as sources of income. Wood fuels are the overwhelming preeminent sources of energy for cooking and for small-scale home industries, such as silk extraction. Even though wood has become more scarce in many areas, it is very unlikely that other sources of energy will totally replace it. Wood fuels, either in the form of fuelwood or charcoal, can generally be managed by the rural people themselves. In most villages, wood fuels can be acquired locally for free or at a very low cost. Even in places where wood has to be gathered from distant sources, after the cost of transportation is included wood fuel is still less expensive than other forms of energy, such as electricity or LPG.

To change to electricity or LPG, much ready cash is needed for equipment purchase and installation costs. Thus, only a few villagers can afford to change. Some villagers said only the local school teacher can afford to use LPG. The operating costs are also higher than those of fuelwood or charcoal. Moreover, it might be very difficult and costly to distribute LPG to remote rural areas. And due to the amount of publicity given to fires and explosions associated with LPG use, most rural villagers, even those who can afford to change, are reluctant to use LPG in their households.

Electricity has reached most villages in the rural areas around Ban Phai municipality, but it is mostly used for lighting, costing the typical household perhaps 50 baht (US\$2) per month. Some of the more prosperous village households also use electricity as a source of power for luxury appliances (i.e., TVs, radios, electric fans, and refrigerators). It is, however, rarely used for cooking, which is the major element in household energy consumption. In cooking, electricity is used only for an electric rice cooker in the preparation of non-glutinous rice, which most villagers eat only occasionally. So rural people may be expected to continue to be dependent on woodfuels. In fact, there probably will be an increase in the overall demand for wood fuel.

At present, rural dependency on income from wood fuels is not as significant as the dependence on it for energy. When wood was still very abundant, many people in rural areas around Ban Phai municipality earned some income by selling fuelwood or charcoal. Due to wood scarcity in most areas, only a small number of villagers now rely on the sale of wood fuels as a major source of income. Of course, for those villagers, most of whom are very poor, wood fuels generate a higher and steadier income than any other alternative activity that is available to them.

5.2 Urban Dependency on Wood Energy

Urban households are not currently as dependent on wood energy as their rural counterparts. In the past, charcoal was used by most middle and high income level urban households because of its cleanliness, while fuelwood was used by most low income households because its cost was low. As wood became scarce, and charcoal occasionally became more difficult to obtain, more and more middle and high income level households began changing to LPG and electricity. Only low income households now still rely on wood fuels, most on charcoal, for cooking. This is also reflected in the distribution pattern; charcoal is increasingly retailed in small packages. The high initial cost of equipment and installation charges prevent these households from turning to LPG. At the same time, because electricity is so expensive, it is not likely that it will be used extensively for cooking in very many urban households.

The situation is almost the same for the commercial and industrial sectors. Due to wood scarcity and government policy, which discourages the production and transportation of wood fuels in large amounts, most commercial and industrial users of wood energy either have turned or are in the process of turning to alternative sources of energy which can be acquired more conveniently and more reliably. It appears that fuelwood and charcoal have largely been replaced by rice husks. Only a few businesses continue to use charcoal, and then only because it meets some particular requirement. Barbequed chicken vendors, for example, need it to provide a special flavor to their products.

Will there continue to be a substantial degree of dependence on wood fuel as a source of energy in urban areas? Urban inhabitants in the study area have more alternative sources of fuel than rural dwellers. And while the demand for wood fuel energy in urban areas persists, the overall level of demand seems to be decreasing. One important indicator is that charcoal has never regained the price level reached during its boom in the 1970s, despite a rise in the urban population. Nevertheless, the demand for wood fuel, especially for charcoal, will probably continue, mainly because households, street vendors, and those who prepare some specialty foods prefer it for certain kinds of cooking.

When compared with their rural counterparts, only a very few people in the urban area rely on the wood fuel business as a source of income. This is because at present the production of wood fuels and their transportation from rural to urban areas is performed exclusively by rural people. In Ban Phai municipality, only the two men who are professional middlemen and distributors are engaged full-time in the wood energy business. These people, of course, have alternative sources of income should they have to abandon the wood energy business.

5.3 General Conclusions

This study confirms the existence of rural-urban dependence on wood fuel in one sub-district in Northeast Thailand, even though this dependence cannot be quantified. The degree of dependence may lessen as wood becomes even more scarce and urban inhabitants shift to alternative fuels. Several conclusions can be drawn:

1. Despite a continuing emphasis by many observers on the contribution of wood fuel consumption to deforestation, rural dwellers confirm earlier research findings that the most important cause of deforestation is land clearance for agricultural use.
2. Wood scarcity and official regulations have made wood fuel systems become more specialized. Producers, collectors, and distributors can be distinguished. As a consequence, the quality of charcoal cannot be regulated by urban traders or consumers.
3. There has been some change in tree management practices among farmers in order to cope with scarcity and to promote tree conservation. In effect, sophisticated tree management provides some wood from branches for wood fuel material.
4. The increase in the price of wood fuel energy is not directly caused by wood scarcity alone. Villagers now have to spend more time acquiring wood, and the availability of alternative forms of paid work has made the cost of wood gathering more expensive, which in turn has contributed to price increases.

5.4 Suggested Follow-up Research Topics

A number of questions and issues were raised in the course of this research that would appear to merit further research. Among the focal points for useful follow-up research, we would suggest the following:

1. Alternative sources of income for landless rural inhabitants now producing wood fuel for sale.
2. Varieties and effectiveness of tree conservation techniques.
3. Opportunities and constraints for reforestation of agricultural land.
4. The effects of land tenure on forest conservation.
5. The effects of local customs on forest conservation.
6. Alternative methods of cooking in urban areas.

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